BATEHAM - Deterioration of Soils of Ohio.

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THE DETERIORATION OF SOILS OF OHIO.

BY M. B. BATEHAM.

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THE DETERIORATION OF SOILS IN OHIO.

BY M. B. BATEHAM.

"Based upon actual observation as to the causes leading to the deterioration, and the best and cheapest means of recuperation."

That the soils of Ohio, especially the older settled portions of the State, have generally declined in productiveness, no one who has given attention to the subject will deny. The fact is generally admitted, and has often been publicly stated at our agricultural conventions, and in the reports and papers.

There is, however, a great lack of definite information as to the extent and kind of soil-exhaustion, as well as in regard to the manner in which it has been occasioned, and the means of its prevention, or the remedies for the evil. Hence, we find the speeches and reports on the subject are too general and vague to be of practical utility to the majority of farmers.

In a residence of over thirty years in the State, most of the time engaged in tilling the soil, and in writing upon agriculture or horticulture, and visiting different sections of Ohio, I have often had occasion to notice instances of the deterioration of soils by their obvious mismanagement, which convinced me that there is a sad lack of information on this subject among the mass of our farmers; and I have had, for several years, a desire to devote some special investigation to this important problem: How can this work of soil-exhaustion be arrested? For, certainly, no problem relating to our agriculture or the future prosperity of the State, is of such grave importance as this.

Accordingly, I made arrangements the past season to visit among the farmers in different counties and districts, for the purpose of making observation on this subject, and at the same time writing a series of articles on "Ohio Agriculture" for the *Country Gentleman.*

The information that I thus gained has convinced me that, although there has been much of soil-abuse and decline of fertility in Ohio, there is not as great a degree of *soil-exhaustion* as has been commonly supposed.

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In other words, I am convinced that the majority of our soils, even where the longest cultivated, still contain a sufficient supply of the essential elements of fertility to allow of their being easily recuperated, when their owners shall set about the work with the requisite intelligence and determination.

In attempting to write an essay on this subject, the difficulty is, the the field is too wide—like the territory of our State—and embraces quite too much for the brief space that can be allowed. In fact, a whole volume might be written on the subject with advantage. In order, therefore, to avoid treating the subject too cursorily to be of practical advantage, it is necessary to divide the field, and take one or two sections at this time, and perhaps give attention to the rest at some time hereafter. Those who heard, or have read, the remarks made at the agricultural convention last year, by Professor Orton, on the soils of Ohio, are aware that there is great diversity in these soils, as to their origin, character or composition, and productions; and all who are at all familiar with our agriculture, know that the various districts or sections of the State often present marked differences as to soil and leading productions; consequently, the methods of farming, or of treating the soil, and of causing its deterioration, are also diverse, and need to be treated of separately in order to be clearly understood.

THE WESTERN RESERVE DAIRY LANDS.

The dairy farming of the Western Reserve is perhaps the most distinct branch of Ohio agriculture, both in its methods and location. It occupies the larger part of the counties of Ashtabula, Trumbull, and Geauga, with considerable portions of Portage, Summit, Medina, and Lorain, besides parts of Lake, Cuyahoga, and Huron. The surface of these dairy lands is mostly undulating or nearly level, and the soil clayey, but differing somewhat in texture, color, and natural fertility, owing, doubtless, to differences of origin. While all of it is of drift formation—not chiefly composed of the ingredients of the underlying rocks—it is evident, I think, that all of it was not drifted into position at the same time or from the same directions; and, also, that some portions were formed more largely than others, by the grinding up and pulverizing of the rocks and shales near at hand. Hence, we find in the eastern section of the Reserve, the dairy lands, while clayey, have more of whitish sand in their composition, derived probably from the conglomerate rocks of the district, mingled with the pulverized shale from the basin of the lake; while the soils of the western section have less sand, are of darker color, and contain more lime, derived from the limestone and shale formations of that and of Lake Erie. We find, therefore, the clay land or dairy soils of Lorain, Medina, and Huron counties more tenacious and also more fertile than those of the eastern section—resembling, in fact, the broad stretch of strong clay soils of the more western counties composing the Maumee Valley, of which so full an account is given by Mr. Klippart, in the agricultural report for 1876.

Owing to their greater depth of fertility and their more recent settlement, the dairy lands of this western portion of the Reserve do not show as much deterioration as those of the eastern and older section; still, there is much decline in productiveness of the older pastures, from the same causes that have been operating so disastrously elsewhere, and which I am about to mention.

The pasture lands of the north-eastern section of the State—the old dairy farms—show the most decline of productiveness of any soils in the State, as far as my observation has extended. I do not believe, however, that these clay soils are so badly exhausted of their natural elements of fertility as many of their owners suppose. On the contrary, I am convinced that they still contain a sufficient supply of nearly all the essential mineral elements, so that with proper tillage and rotation of crops enduring productiveness would be generally secured.

In proof of the absolute necessity of reform in the management of the dairy farms, I would state from personal observation and inquiry, as well as from the testimony of experienced resident farmers, I am convinced that the average productive capacity of the pastures has declined fully one-half, or fifty per cent., in the past twenty years. At a meeting of dairy farmers held at Jefferson, Ashtabula county, last September, at my special request, for the discussion of this subject, the extent of the evil as just stated was distinctly avowed and sustained, though denied by some farmers, who evidently owned better lands than the average, and had treated their pastures more rationally. I was present also at a similar meeting of dairy farmers in Geauga county, where the same topic was discussed, and the same general facts were admitted, though with seeming reluctance, and with evident anxiety in regard to the future, or the way out of their difficulties.

The statistics, or assessors' returns for these counties, also confirm what has been stated as to the extent and rate of decline of the pastures. We have the amounts of the pasturage only for the past eight years, and taking the first two and the last two years of that period (so as to avoid temporary causes of variation), we have as follows:

ASHTABULA COUNTY.

YEARS.	No. sheep.	No. cattle.	Acres pasture.
1868	87,524	32,211	119,870
1869	83,107	32,323	113,381
1875	24,406	36,202	132,340
1876	25,410	35,227	142,408

Geauga county has less than two-thirds as much territory as Ashtabula, but is more exclusively devoted to dairy farming. The corresponding figures for Geauga are as follows:

YEARS.	No. sheep.	No. cattle.	Acres pasture.
1868	40,996	25,697	94,312
1869	27,691	24,741	93,464
1875	15,218	22,297	120,643
1876	18,761	22,353	120,698

Seven to nine years ago, it will be remembered, dairy farming was found more profitable than sheep farming, and in consequence most of the sheep in these counties were sold off to make room for cows. But owing to the already reduced production of the pastures, which had for some years been overstocked, it was necessary to increase the amount of pasture lands in order to keep up the number of cows. Hence, by analyzing the figures, we find that the number of acres of pasture in each county was increased in the eight years over thirty per cent., while the amount of stock maintained was actually reduced. If we estimate the sheep by the usual rule, counting eight sheep as equivalent to one cow, we shall find that in 1868 the amount of pasture was at the rate of a little less than three acres to each cow, while in 1876 it was at the rate of over four acres to each in Ashtabula, and a trifle less in Geauga; and this latter rate accords with the facts as I found them on the average dairy farms the past season. And even this rate is found to be more than the pastures can maintain without injury, so that large numbers of cows have recently been sold off, especially from Ashtabula county. In fact, the business of dairy farming, as it has been conducted, with the prevailing prices of the products, has become so unprofitable that many of the farmers are of necessity keeping a less number of cows, and say they intend to devote more of their land to plowed crops.

The necessity for this change will appear from what has been said respecting the income from the soil. A farm of one hundred acres will only maintain an average of a dozen cows and a pair of horses. These will require not less than fifty acres of pasture, and twenty-two acres of timothy meadow for hay. Counting six acres for orchard, garden, and buildings, there remain twenty-two acres for plowed crops. As the timothy will not hold good more than three years on an average, one-third, or seven acres, must be seeded afresh each season. The usual rotation, therefore, is a simple three-years shift—first year, seven acres of timothy sod, with manure, plowed under for corn and a few potatoes; second year oats, and third year manure again and seed with wheat and timothy.

As a rule, the dairy pastures are never plowed and are never manured, except from the droppings of the cows. All the manure saved on the farm is required and used for keeping up the fertility of the land used for plowed crops and meadow. All of the grain produced, except a little wheat, is commonly needed for feeding during winter and spring, and in times of drouth; so that very little besides milk, or its products, can be sold off the farm; and as the average cash proceeds of the cows is only thirty to forty dollars each per year, any one can see that the net income of such a farm is very small indeed, and it is no wonder that the farmer's sons are seeking other homes and more profitable occupations.

HOW DETERIORATION HAS BEEN CAUSED.

It is usual for the writers who undertake to explain how soils become exhausted, to begin with quotations from the formulæ of agricultural chemists, Liebig, Johnston, and others; and showing by analyses what elements of the soil are removed by successive crops, lead to the conclusion that some of the essential elements of fertility have become exhausted or deficient in quantity. This being settled, of course there is a short and easy method of solving the problem, How to restore fertility; for it is only necessary to discover what elements are wanting, and then supply them! Those, however, who are familiar with the practice as well as theory of agricultural science, are aware that farmers have met with difficulties and disappointments in their efforts to derive profit by these teachings; and I find there is at this time much of prejudice in the minds of the majority against any arguments derived from the lessons of agricultural chemistry. This is to be regretted, and will need to be overcome before much progress can be made in restoring the fertility of soils; for the science of agricultural chemistry underlies all improvement in this line. In deference, however, to this popular feeling, and hoping thereby to make this essay more generally useful, I shall seek to avoid, as far as possible, the use of scientific terms and formulæ. I can do this the more readily, as the class of soils of which I am now treating, do not, in my opinion, show much exhaustion of their mineral ingredients, but chiefly the need of a better system of management.

When first cleared of the forest, these clay lands were rich in vegetable matter from the decayed leaves, etc., and the mineral elements of the surface soil were readily available for plant growth. So well suited was the soil for grass, that red-top, blue grass, and white clover came in spontaneously, after a year or two, without any seeding; though, of course, it was better to sow the seed and harrow or brush it in, when it was desirable to save time. But a large portion of the pasture never have been seeded nor plowed. When seeding was practiced it was by sowing timothy, and in a few years this gave place to the grasses above named, which came in of themselves. For some years these pastures were quite productive; the vegetable matter at the surface, and decaying roots of trees beneath, keeping the soil porous and fertile. But gradually this organic matter was all decomposed, dissipated by the winds, or absorbed by the grass roots, in the form of carbonic acid gas. Then the clay soil began to harden by the saturation of rains and the treading of cattle while wet, rendering it difficult for grass roots to penetrate to any depth, and there being no organic matter below the surface, no fertilizing gases were found there, and none could enter from the atmosphere. As this hardening process went on, the grass roots could only grow on the surface, and hence were often injured or destroyed by the summer drouths, and also by the heaving and freezing in winter. Hence we hear the farmers complaining that drouths are more frequent and injurious of late years than formerly, and the winters more severe and destructive. If the surface is undulating, the water from summer rains runs off at once, instead of entering the soil where it is wanted; and if at all flat, the water in raining times, stands in many places, and this brings in sedges and other worthless weeds in place of useful grasses.

Too close feeding is another prominent cause of deterioration. Most of the dairy farmers admit that they have all the time kept more cows than was for their interest in the long run; but some present emergency is made the excuse. As a consequence, they have been obliged to turn their stock out to pasture before the grass had made a good start in the spring, and it was kept fed off closely during the drouths of summer, and until severe frosts came on in the fall. Every farmer should know that no plants can thrive, or make healthy roots, without being allowed to make leaves. Even Canada thistles and quack grass are killed by keeping the leaves cut off, or fed closely with sheep: and the owners of suburban residences have found out that the sod of their nice lawns can be ruined by the too frequent use of the lawn-mower. Such close feeding as has been practiced by many of the dairy farmers, along with the other causes, could not fail to prove destructive to the finer grasses. This is sufficient, also, to explain why it is that "poverty grass" (*Danthonia*) and other weeds which cattle will not eat, seem to thrive where the useful grasses die out. Not being cropped off like the rest, they, of course, have full chance to grow.

Lack of some mineral elements, I have no doubt, is another cause of deterioration in these old pasture soils. In order to learn about this, I have taken pains to make special inquiry as to the results of experiments that have been made in the use of lime, ashes, superphosphate, and ground bone as fertilizers upon these soils. Some of the farmers have told me they thought lime would be beneficial, if it was not so expensive. But from partial analyses that have been made, as well as from experiments in its use, I am convinced that lime is not generally wanting. Nor do I think that potash is lacking as a rule, although in most cases ashes are quite beneficial on old pasture soil that is less compact than the average; but experiments with ashes on these clay lands have generally shown but little benefit, and chemical analyses prove that clay soils usually contain sufficient potash.

Superphosphate has been used by quite a number of dairy farmers within a year or two past, and always, I think, with advantage to pastures or meadows, if applied early in spring. Ground bone contains more phosphorus, and is found of more benefit, in proportion to its cost, than superphosphate. One enterprising dairy farmer in Geauga county has used the bone dust quite extensively the past two years, and finds it pays well on old pasture as well as meadow, showing that phosphoric acid has become exhausted from the soil—at least from the thin surface permeated by the grass roots; and this, in some cases, is probably the chief cause of deterioration, as phosphorus is the choicest mineral element of our soils. Healthy grass or grain crops can not be grown without phosphoric acid in the soil. It is an essential element in grain and straw, and in grass and hay; it goes to form the bones of animals, and is a constituent of milk and cheese. With these last facts in view, it is easy to understand how this element becomes exhausted from the dairy soils. It is carried off in the twenty-five million pounds of cheese annually exported to Europe and elsewhere from our State. It is also carried from our farms in the cattle, sheep, wool, and grain sold off annually. When this element is wanting in the pastures, cows become uneasy, and their milk unsound, like those long deprived of salt. They sometimes show their need of phosphate by gnawing any bones they may find, like a dog. This, I have been told, is frequently seen on these old farms. Some of the teachers of dairy farming now recommend giving ground bone to cows occasionally in their feed, to make up for this deficiency in their pastures.

HOW TO RECUPERATE THESE DAIRY SOILS.

1. " *With brains, sir*," was the suggestive reply of a noted English agriculturist, when asked how worn out lands could best be fertilized. So I am compelled to say, what is most needed at the outset, for the recuperation of these dairy soils, and the improvement of agriculture generally, is more brain work or mental activity, and sound knowledge on the part of the generality of farmers. From what I have found, I do not think more than one-fourth of the farmers even on our boasted Western Reserve are habitual readers of any agricultural journal; and not over one in ten of the farmers of the State generally. And scarcely one in a hundred has taken pains to learn even the first rudiments of agricultural chemistry—the science upon which all improvements in land tillage are based! With such prevailing mental apathy one would despair of seeing any improvement in agriculture or of recuperation of soils during the present generation, were it not for the stimulating example of the few active brain-workers found in every county.

2. *More Muscle*, as well as mind, needs to be devoted to the work of recuperating these dairy farms. It is an unwelcome statement, but I am statisfied 'tis true, that our dairy farmers, as a rule, perform less physical labor than any others in the State. A prominent farmer and cheese maker in Medina county, speaking to me on this subject said he regarded the dairy business as a source of damage to the farming community, in that it fostered habits of indolence, and the young men grew up with a distaste for such work as is found necessary in a mixed style of farming.

3. *More Variety of Products*, and less of the land devoted to pasturage, would be better for the soil and its owners. In fact no thorough system of recuperation can be set in operation without such change. This, it is true, will demand more labor than many of the diary farmers are able or willing to bestow, and more capital than they have at command; but it will be found to pay in the end, as has been abundantly shown by the examples of a few progressive farmers that might be named in Geauga, Summit, and Ashtabula counties, where there are some as prosperous mixed farmers as can be found elsewhere.

4. *Plowing up the old pastures*, is of course necessary in order to recuperate them; but this must be done cautiously, and not deeply at first, or so as to bring much of the impervious clay on to the surface at one time. But after a year or two of exposure to frost and air, a little more depth may be given, especially if a green crop of some kind, or a dressing of manure is turned under. Plowing in the fall, and laying in narrow ridges for the winter, is very beneficial to such soils; as the frost and snow impart mellowness and increased fertility.

5. *Pulverizing the Soil*, by harrowing frequently, when in right condition, and using a clod-crusher when lumpy, will be found of immense benefit, not only when preparing the soil for planting or seeding, but at all times when it can be done; the object being to expose all the particles of soil, as far as possible, to the action of the atmosphere, thereby setting free and rendering available, supplies of potash, phosphorous and other fertilizing elements locked up in the solid clay, at the same time that carbonic acid and nitrogen are absorbed from the atmosphere and rains.

6. *Draining.*—Of course underdraining would prove the most effective and enduring means of improving these clay lands, if the expense could be afforded, but for pasturage mainly, few men would think it could pay. Some old worn-out pasture fields near Hudson, in Summit county, have been underdrained at a cost of about $60 per acre, and then used for hay and grain crops, with such complete success that the owners assured me the investment for drainage paid not less than twelve per cent. annual interest, and more than doubled the value of the crops. Where underdraining cannot be afforded, enough surface drains should be made to carry off all standing water, and prevent if possible that saturation during winter which leaves the soils lifeless and solid in spring—all the air having been expelled, and the process of cohesion filled its place.

7. *Green Crops*, plowed in as manure, are specially beneficial as a means of cheaply recuperating these clay soils, first, by affording direct nutriment from their decomposition to the roots of plants; second, also by their mechanical effect in making the soil porous, so that rain and atmospheric gases can have access to the roots; and third, that the carbonic acid generated by decomposition or attracted from the air, may render soluble the mineral ingredients of the soil. Straw or other litter, or even saw-dust, plowed in, will have similar effect, but fresh saw-dust, if used freely, sometimes proves injurious to the succeeding crop by causing mildew in the soil.

8. *Common Manure*, if it can be had, is of course an efficient agent in recuperating all exhausted soils. Dairy farmers, and others generally,

do not use sufficient care in saving and increasing the supply of this article. Its application is more beneficial, however. to soils that have been frequently plowed, and exhausted by cropping, than these old pasture lands, which have only been exhausted at the surface. The means of increasing manure by the use of muck, saw-dust, etc., to absorb the liquid in stables, and by other methods, will occur to the minds of all who really seek to improve.

9. *Top Dressing Pastures with Manure* is a good means of preventing deterioration, where the grass has not become too thin to be worth preserving. It should be done the latter part of winter, when the snow is off, and at a time when the ground is frozen, or so dry that wheels will not cut in.

10. *Mineral Fertilizers*, especially ground bone and superphosphate, as I have already said, are no doubt highly beneficial. Of the two I am convinced that pure bone is the most economical, as the ingredient most wanted is *phosphoric acid*, and analyses show that there is twice as much per cent. of this in pure bone as in the average superphosphates. The idea that the phosphoric acid in pure bone is not in a state to be available as plant food, I am convinced is a mistake, provided the material is finely ground, as is done at the Salem, Ohio, mill. I have had proof of this in my own experience the past two years, and much testimony from others to the same effect—see remarks a little further on.

11. *Rotation of Crops* is needed for pasture lands as well as others. Nature loves variety, and it is only on soils of extraordinary fertility, like those of the blue-grass regions in the Scioto and Miami valleys, that pastures will not run out or deteriorate in a few years, especially with the hard tramping and cropping they commonly receive. Hence it is vain to expect to recuperate the old dairy pastures economically, or to maintain others *permanently* in these dairy districts. This feature of dairy farming must shortly be changed, and dairying be made a part of more general farming, instead of so much of a specialty. Then the pasture fields will come into the system of rotation, and be renovated by plowing and manuring, with change of crops every few years, so that vegetable matter will be mixed in the soil, and its mineral elements made available, and so that grass roots will find access and nourishment six inches in depth, instead of only two inches as heretofore. It is my belief that those dairy farmers who soonest accept these obvious truths, and conform their practice to them, will be the best off in the future, for it is easy to see that the present system must soon come to an end.

12. *Using a Mixture of Grasses*, instead of timothy alone, or with blue-grass, when seeding for pasture, I have no doubt will be found of much

advantage on these dairy farms. Five or six kinds will yield more herbage and endure much longer than one or two. English farmers understand this, and use a mixture of six or eight kinds for permanent pastures and half as many for meadow.

Of course, where it is necessary to bring the land under the plow often, by means of a short rotation, timothy alone may do as well. Of the grasses that are known to flourish on clay lands and make good pasture, I would name the following six as forming a desirable mixture: Timothy (*Phleum prætense*), blue-grass (*Poa prætense*), red-top (*Agrostis vulgaris*), orchard grass (*Dactylis glomerata*), rye grass (*Lolium perenne*), meadow fescue (*Festuca prætense*). The seeds of rye grass and fescue are not often saved in this country, but are annually imported, and can be had at reasonable prices from the leading seedsmen. The meadow fescue grass has been gradually coming into the northern parts of the State, in some way, for a number of years past, and flourishes finely along the roadsides on clay soils where a little moist. It is highly esteemed in England as a pasture grass, though cattle do not seem quite as fond of it as of timothy and blue-grass.*

MIXED FARMING SOILS—EASTERN BORDER—COLUMBIANA COUNTY.

In speaking of the mixed farming soils of eastern Ohio, I take Columbiana county as representative of the district, so as to make some use of official statistics. It has always ranked among the best agricultural counties of the State, and in early times was noted for the production of wheat and wool. Its original settlers came mostly from eastern Pennsylvania and Maryland, and were sensible and industrious farmers—a good sprinkling of them of the Quaker order, and of course not very progressive, though friendly to education and good morals. The soil of the county was quite good, and suited for a diversity of products; the northern portion level and clayey, but most of the county rolling and rich loamy soil, with intervals of alluvial. With such lands, and ready access to market, and a large number of workers in coal, iron, and pottery, as consumers of produce, it was natural that farming should flourish, and the county become thickly settled.

Thirty-one years ago, when I was editing the *Ohio Cultivator*, and acting as secretary of the infant State Board of Agriculture, I visited Columbiana county while on a tour of observation, and was gratified to find the farmers had that season organized a county agricultural society, under the "act for the encouragement of agriculture," which was passed only two or three months previous; and from the interest then manifested I was led to expect that Columbiana was going to lead the rest of the counties in the march of agricultural improvement; or, at any rate, would be far ahead of her present position after the lapse of thirty years. In visiting the county again, the past fall, I was surprised to see how little change had taken place in that time, as compared with other sections. Almost everywhere, away from the immediate railway depots and manufactories, were the same old quaint-looking towns and farm buildings, and a majority of the people, though not in Quaker garb, seemed to manifest, in speech and action, more of mental and bodily composure than is consistent with much desire for improvement. I found, too, that here, as elsewhere, farming had fallen into such disrepute among the young men that a majority of them had left the occupation and homes of their fathers for other places and pursuits, and comparatively few of the present farmers have the courage or ability to bestow as much labor on the tillage of their soil as is necessary in order to maintain its fertility. It was thought, however, that the business revulsion of the past few years had effected some improvement in these respects, and farming was becoming more respectable in popular estimation, so that a few young men of mind and enterprise are beginning to engage in it.

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* The foregoing hints on recuperating the soils of the Reserve will of course generally apply to many other portions of the State, as clay soils abound almost everywhere.

The deterioration of soils in this region is not so marked as in the dairy sections, but is none the less real; and it may be found more difficult to remedy, because the exhaustion, though less noticeable, is of greater depth. In early times wheat was the staple crop of the county. In the first annual report of the county society (1846) the President, Samuel Myers, said: "Wheat and wool are the principal products of the county. * * * The average yield of wheat the past season is believed to be twenty bushels per acre; of corn, forty bushels. * * * Number of horses, 8,376; cattle, 14,061; sheep, 96,978. * * * In the cultivation of wheat we think our county is surpassed by few, if any, in the State, and in the production of *wool* we believe our county is in advance of any other." Ten years later (1856) the President and Secretary of the Society reported that the annual average yield of wheat was eighteen to twenty bushels per acre; but for several years the weevil had materially injured the crops. Twelve years later still (1868) was the first year that statistics of pasturage were given; and we find the following returns for the county: Acres of wheat, 16,165; bushels, 168,050; average per acre, 10.39; number of sheep, 200,056; cattle, 16,851; horses, 8,215; acres of pasture, 64,028; meadow, 27,300; tons of hay, 7,736. After eight years more (1876) we have the following figures: Acres of wheat, 16,142; bushels, 193,924; average per acre, 10.68; acres of pasture, 76,634; acres of meadow, 31,548; tons of hay, 34,623; number of sheep, 102,446; of cattle, 13,546; horses, 8,116. That the foregoing items are not exceptional, is shown by the figures for the preceding and following years. The wheat crop of 1875 averaged only nine bushels per acre. This was a bad year generally for wheat; but the average for the adjoining county of Stark was 13.32, and that of thirty-three counties in the northern section of the State was 14.32. If we analyze the other items we find that the number of sheep was reduced 97,510, or nearly one-half, during the eight years; and that of cattle was reduced 2,305; while the number of acres of pasture was *increased* 12,606, and of meadow 4,226 acres.

Such an amount of decline in the productiveness of the soil as these figures indicate is sufficient to account for the low esteem in which farming is held by the young men; for such a decline is enough to make all the difference between profitable and unprofitable labor, or between comfortable subsistence and debt or privation. The facts ought to arouse the people to earnest inquiry as to the means of recuperation, and active efforts for their adoption.

How the deterioration of these soils has been brought about, cannot be stated in few words, except by saying it has come from the common system of poor farming generally—robbing the soil of its elements of fertility, so as to render their recuperation difficult or expensive. The land has been managed much as though the owners were all tenants, and were expecting to leave in a year or two. But few have practiced a judicious system of rotation, or taken sufficient pains to deepen and pulverize the soil, so as to admit air and moisture, and enable crops to withstand drouth and frost; and fewer still have seemed to understand the value of manures, or how to increase or use them; though there are some praiseworthy exceptions to these disparaging remarks.

In my tour the past fall, I found the farmers here, as elsewhere, very much encouraged by the exceptionally good wheat crop of the season just past. This and the good prices of farm products generally, had caused a more cheerful feeling than had existed before for some years. As a consequence, a number of business men were engaging in farming, and special efforts were being made to sow as much land as possible with wheat, in the hope of realizing another big crop next year—though it is probable this hope will be disappointed. A good deal of land had been sown to wheat, with but indifferent preparation, and with less than the usual share of manure or vegetable matter plowed under—the owners trusting to "good luck" for the result!

The same causes that have been mentioned as operating injuriously in the dairy soils, have been at work here. Pasture lands are left too long without plowing, or any kind of fertilizing, while at the same time they have been kept fed off so closely, with sheep and cattle, as to kill out the useful grasses. When the land is plowed for seeding to wheat and grass, not enough vegetable matter is plowed in to prevent the soil from packing solid when saturated with rain; then the wheat and grass heave out by frost, and bare spots appear in spring. Often, too, the timothy meadows are pastured off in the fall, and this weakens the roots so that they winter-kill. Lack of some mineral element, as has been said before, is, no doubt, also a cause of decline in the wheat and grass crops.

The remedies have been already suggested by naming the causes of the mischief. Let the causes be removed and the effects will soon cease. If nine-tenths, instead of only one-tenth, of the farmers would subscribe for and read agricultural journals, and fifty young men of the county go and attend the course of lectures about to commence at the State Agricultural College, there would be no doubt in my mind as to the speedy renovation of the soils and the farming of Columbiana county, or any other county in the State.

Bone Fertilizing for Wheat and Grass.—In Columbiana, and parts of several counties adjacent, I learned that numerous experiments had been made, within the past two years, in the use of superphosphate and ground bone as fertilizers for wheat and grass; and the results have been so generally favorable as to render it clear that phosphorus is the element most wanting in these lands for the production of these crops. Local agents for the manufacturers of superphosphate at Buffalo and Cleveland, had been quite active in distributing circulars and advertisements to farmers, thereby inducing them to try these articles by way of experiment. Mr. Schilling, the proprietor of the bone-mill at Salem, had also prompted many of the farmers in that section to test his raw-bone flour in comparison with the superphosphate. I began to hear good accounts of these experiments while in Mahoning county, on my way to Columbiana; and some men of Youngstown told me there was such a demand springing up for the bone-flour that they had intended to erect a bone mill at that place, but they found, on inquiry, that expensive machinery was needed for making a fine article, and they also apprehended that the supply of bones would perhaps give out by the time they got their mill well going. On visiting Salem, I found the farmers in that vicinity had nearly all got *bone on the brain*; some of them seeming to think that stable manure was no longer of much account, and bone-flour was going to give new life to their old wheat fields and cause a general revival of agriculture. On going to the mill, I was surprised to find that for some weeks past, although the mill had been running night and day, grinding at the rate of five to six tons daily, the supply was not nearly equal to the home demand; and farmers' teams were then present, waiting their turn for a few hundred pounds to finish their wheat sowing, or a barrel or two just for experiment. Sometimes the farmers came from a distance of fifteen or twenty miles, and brought a lot of bones along to exchange for the ground article; but the bulk of the supply of bones came by the cars from the cities in Ohio and elsewhere, where beef-slaughtering is done, and occasionally a few car loads of buffalo bones are had from the far west.

Feeling much interest in this fertilizing question, as suggesting a method of soil recuperation, I spent a couple of days visiting and talking with the farmers around Salem. I found that some of them who at first had no faith in bone-dust, were now strong advocates of its use—for those who at first refused to try it, could not help seeing its results on the crops of their neighbors who had used it. The benefits were more marked on the light crops of wheat in 1875 and 1876, than on the full crop of the past season; but much of the advantage is found to result to the grass crops succeeding the wheat. I walked over numerous fields of grass and clover sown the year before, and certainly the results of the fertilizing were quite remarkable. I have also had statements by letter from farmers in Stark, Portage, and Mahoning counties, that fully corroborate all that was told me around Salem. Some of the experiments were along side of those made with superphosphate, and in almost every case the result was in favor of the pure bone, especially when the duration of the benefit, or its effect on the second crop as well as the first, was taken into account. The superphosphate in most cases manifestly helped the crops in getting a good start, but unless liberally applied and worked into the soil, its effects did not last until the harvest, like those of the bone-dust. A farmer of Mahoning county wrote me that one year ago three tons of the bone flour were used in his township (Boardman), and the results were so satisfactory that double the quantity was used the present year. And a farmer at Palmyra, in Portage county, told me that he and a number of his neighbors had been using the article for two or three years, with much advantage, on a variety of crops. Similar accounts have come to me from the eastern townships of Stark county.

It has been stated by writers on agricultural chemistry, that in order to make the phosphoric acid of bones soluble, and thereby readily available as a fertilizer, the bones need to be first converted into superphosphate, by treatment with sulphuric acid. But as this operation is expensive, and causes a large increase of cost and of weight for the same amount of phosphoric acid, it is important to determine whether such treatment is necessary; and all the experiments of which I have learned go to prove it is not, but rather a disadvantage. There is also more liability of fraud or adulteration in the manufacture of superphosphates than of bone flour.

As this matter of the speedy availability of pure ground bone is of much practical importance, I give the particulars of an experiment directly in point, communicated to me by Messrs. Hough and Son, farmers and fruit growers of Rootstown, in Portage county. The crop was buckwheat, the latest sown and quickest of growth of all farm crops, hence the best for testing this question. A field of five acres was sown the last of June. The soil was in fair condition as to tilth, but poor, and having one barrel of Salem bone flour on hand, it was applied as a fertilizer upon one-half of the field as an experiment; sown broadcast and harrowed in with the seed, then rolled. Rain gave the seed a start, and no doubt hastened the effect of the bone, for as soon as the plants were fairly up there was a noticeable difference between the two parts of the field in the breadth of the leaves and vigor of growth. This difference was more marked as the crop advanced, and the result was, the fertilized half yielded fifty-five bushels of nice grain and the other only six bushels.

The idea that ground bone is not readily soluble or fit to be absorbed by the roots of plants, has, I think, grown out of the fact that the material is commonly two coarsely ground—perhaps owning to the cost of good machinery. At the late meeting of our State Horticultural Society in Ravenna, Mr. Schilling exhibited samples which he had obtained from six or eight different establishments, in various States, and of a majority of these, the particles averaged the size of grain of wheat, and some as large as grains of corn. A magnifying glass also revealed the fact that several of the lots were adulterated with stone or shale.

The facts that I have stated, proved conclusively, as I believe, that the chief mineral element wanting in the deteriorated soils of our wheat and grass farms, is phosphoric acid, in an available form; and hence it is probable that *bone fertilizing*, along with plowing in clover and other green crops, and manures, is the true system of recuperation. It is not my belief, however, that the natural store of phosphates or other inorganic elements, has really become exhausted from much of the soils of Ohio, except at the surface. But there is need of more thorough tillage, and opening of the soil to the atmospheric agencies, as has been already stated, to render the mineral elements more available for the roots of plants. And this brings us back to the fact that our first and greatest want is more light and knowledge on all these points.

In view of this fact, and of the general apathy that prevails on the subject of agricultural improvement, the great question seems to be, how can the minds of the farmers generally be awakened so as to induce them to devote more intelligent efforts to the work of increasing the fertility of the soil? As one means to this end, I would suggest that the holding of "Farmers' Institutes" in the several counties, at which one or more of the Professors of the Agricultural College, and other competent lecturers should be present, and topics like those of this essay be discussed—would be likely to prove of much benefit, especially to that large class who are but little inclined to read on these subjects.

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